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Social Science and Medicine

DOI:
https://doi.org/10.1016/j.socscimed.2020.113016

Published: 01/08/2020

Peer reviewed version

Mental health consequences of minority political positions: the case of Brexit

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Conflict of interest statement: Dr. Saville has nothing to disclose.

Funding: This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Acknowledgements: I am very grateful to Sophie Baker and Rob Ward for useful comments on the manuscript, to Jenny and Time Saville for proof-reading, and to two anonymous reviewers for their helpful comments.

Abstract

The group density effect, where a group member's psychiatric risk is associated with the proportion of the local population their group comprises, demonstrates the importance of minority group status to mental health. Previous research, focusing on ethnicity, has been correlational, but newly-formed identities provide opportunities for natural experiments, with greater scope for causal inference. This study examines whether such a group density effect can be found for the novel Brexit identities of 'leaver' and 'remainer' following the UK's divisive 2016 referendum on EU membership.

Mixed effects models were fitted to the Understanding Society panel survey series (N=25,555, 19,767 for analyses controlling for pre-referendum mental health data), predicting mental health as a function of individual opinion on EU membership and local referendum results. These interacted such that those holding the local majority opinion had better mental health (Odds ratio (OR):.875 [.766-.9995]), compared to those in the minority. This result survived adjustment for individual and area-level economic circumstances (OR:.866 [.758-.989]), and, strikingly, pre-referendum mental health (OR: .841 [.709-.998]), as well as a number of other potential confounding variables.

The results provide evidence for rapidly forming group density effects based on *de novo* identities, and suggest that identity may be a causal mechanism for group density effects more broadly. They also speak to the extent of polarisation in the Brexit-era UK, and its public health consequences.

Keywords: *UK; Brexit; ethnic density; social identity theory; inter-group relations; group density; social epidemiology; public mental health*

- Previous group density studies correlational and unable to establish causation
- Novel identities from UK's EU referendum allow study of formation of this effect.
- Density effect evident post-referendum but not beforehand.
- Effect robust to adjustment for a number of possible confounding variables

Being in a minority can be an uncomfortable experience. One striking demonstration of the psychological consequences of minority status is the group density effect, where the mental health of a member of a minority group is positively correlated with the proportion of the local population belonging to the same group (Shaw *et al.*, 2012). The majority of group density studies have focused on ethnic minorities, but this phenomenon has also been found for sexual minorities (Hatzenbuehler *et al.*, 2011) and social classes (Schofield *et al.*, 2016). Proposed mechanisms (Bécares *et al.*, 2009) echo some of those identified in the broader literature on minority health inequalities: experience of discrimination and stigmatisation (Meyer, 1995; Clark *et al.*, 1999), status anxiety (Layte and Whelan, 2014), and access to culturally-specific sources of social capital (Whitley and Prince, 2005).

Group density designs, however, fall well short of the criteria of causal inference (Hernán and Robins, 2020). They implicitly assume that that people from the same group living at different levels of group density are otherwise equivalent, differing only in the degree of minority status they experience. Such an assumption is questionable and it is possible that some or all of this phenomenon is compositional rather than contextual, reflecting the self-selecting nature of where people live. The human and economic geography of where minority and majority groups live, why individual members of groups may not live in their group's enclaves (gentrification, social mobility etc.), and other concerns are products of the long histories of these group identities. This is also major part of the problem with causal inference in this field because there is no 'time zero' before which the group density effect did not apply. Thus time cannot be used as a contrast to help isolate causation.

However, as shown by the pioneering work of Tajfel and Turner (1979), identity can be dynamic and even arbitrary characteristics can be adopted as features of one's identity if these characteristics can be made salient. A possible approach to improve internal validity would be to take advantage of a newly salient social identity and use it as the basis for a group density study. Then analyses can account for participants' mental health prior to the identity becoming salient to test whether any group density effect coincides with the newly salient identities.

One such example is the identities of 'leaver' and 'remainer' in the Brexit-era United Kingdom (UK). On the 23rd of June 2016, the UK voted 52 to 48% in a referendum to leave the European Union (EU). The

UK's membership of the EU had previously been a fairly low salience issue – YouGov's tracking poll asking respondents to identity the three most important issues facing the country found that 19% picked 'Europe' in the first poll of 2015 (YouGov Ltd, 2015) – but, following the referendum, came to dominate British politics – 62% picked 'Britain leaving the EU' in the first such poll of 2017 (YouGov Ltd, 2017). But Brexit is not just a conventional political squabble, it has led to strong affective polarisation between the de novo social identities of remainer and leaver. These identities have become at least as strong than traditional party affiliations, according to survey (Hobolt *et al.*, n.d.) and behavioural economic (Murray *et al.*, 2017) evidence, and, strikingly, only a minority of respondents say they would be happy if their child married someone with the opposing view (Hobolt *et al.*, n.d.).

These Brexit identities have a strong geographical quality. Changes in economic geography have created place-based political and cultural divides, with urban centres diverging politically and culturally from towns and rural areas (Jennings and Stoker, 2019). The geographical aspect to the Brexit vote is not a purely academic observation, but has become is central to how the identities of remainers and leavers, living in 'Remainia' and 'Brexitland' respectively, have been framed and constructed (Sykes, 2018).

Research supports the idea that Brexit has been a sufficiently emotive event to impact people's mental health. Powdthavee *et al.* (2019) found that poor mental health was both a likely driver of the Brexit vote and a consequence of it. Vandoros *et al.* (2019) used a difference-in-differences analysis of anti-depressant prescriptions relative to iron and anti-gout medication, finding that there was a relative increase in anti-depressant prescriptions compared to the control medications. Kavetsos *et al*,(2018) used a difference-in-differences between respondents to the Eurobarometer survey series in the UK and those in other EU countries, finding a relative decline in mental health among UK respondents with a positive or neutral opinion of the EU. Frost (2020) found an increase in UK-based migrants' anxiety, which was larger in more leave-voting areas. Finally, Katshu (2019), reports a case of an acute psychotic episode that appeared to be induced by the referendum.

Given this strong and geographically-loaded group polarisation, combined with evidence of a measurable impact of Brexit on mental health from other studies, it seems plausible that those holding a view that is in the minority locally may be vulnerable to some of the consequences of mental ill health demonstrated

by other kinds of minorities in the literature. The fact that these identities either did not exist at all prior to the referendum, or at least were much less salient, allows us to carry out a natural experiment of group salience, a novel approach in group density effect research.

Data and methods

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The University of Essex Ethics Committee has approved all data collection on Understanding Society main study and innovation panel waves, including asking consent for all data linkages except to health records. Requesting consent for health record linkage was approved at Wave 1 by the National Research Ethics Service (NRES) Oxfordshire REC A (08/H0604/124), at BHPS Wave 18 by the NRES Royal Free Hospital & Medical School (08/H0720/60) and at Wave 4 by NRES Southampton REC A (11/SC/0274). The analyses reported here were approved by Bangor University School of Psychology Ethics Committee (Ref: 2019-16690).

Data were used from Understanding Society (University of Essex, Institute for Social and Economic Research *et al.*, 2019), a household panel survey with participants across the UK. Special licence data with respondents' UK parliamentary constituency of residence were accessed, following permission from the data owners, via the UK Data Archive (http://doi.org/10.5255/UKDA-SN-6614-13). The main analyses used Wave 8 (2016-2018), supplemented with mental health data from waves 4-7 as detailed below. The control analyses of pre-referendum data used the pre-referendum portion of Wave 7 (2015-2017).

The following variables were used from Understanding Society (with variable names in the data file) given in parentheses): the 12-item General Health Questionnaire (GHQ, Goldberg and Blackwell, 1970), a screening instrument for mental health, specifically the 'caseness' summed score (*h_scghq2_dv*), dichotomised so scores of 0-2 indicated better mental health and scores of 3-12 indicated poorer mental health (the most widely used dichotomisation threshold Goldberg *et al.*, 1997); opinion on the UK's membership of the EU, measured with the question 'Should the United Kingdom remain a member of the European Union or leave the European Union' (*h_eumem*); sex (*h_sex*); age (*h_age_dv*); the month (*h_intdatm_dv*) and year (*h_intdaty_dv*) of interview; total net weekly personal income (*h_fimnnet_dv*); the

two digit Cross-National Equivalent Files classification which industry respondents' current job comes under (*h_jbiindb_dv*); household ID (*h_hidp*); parliamentary constituency (*h_pcon*); individual sampling weights (*h_indinus_lw*); ethnicity (*ethn_dv*), dichotomised into white British/English/Scottish/Welsh/Northern Irish and all other ethnicities, to avoid issues of multicollinearity; whether or not respondents were born in the UK or not (*bornuk_dv*); and finally the most recent pre-referendum dichotomised GHQ score (*e_scghq2_dv, f_scghq2_dv,* or *g_scghq2_dv),* if one was available in 2014-2016.

Equivalent data were used from Wave 7 for the pre-referendum control analysis, but linked to Wave 8 data for opinion on EU membership, as this question was not asked in Wave 7.

These data were linked to two geographical datasets: estimated constituency-level results from the EU referendum and area-level poverty. Official Welsh, English, and Scottish results were reported at the local authority level, while Northern Irish results were reported at constituency level. Given that the populations of local authorities vary by orders of magnitude while constituencies are roughly equivalent in size, Hanretty's widely used (Hanretty, 2017) estimates of constituency-level referendum results were used. Area-level poverty was operationalised as the proportion of working age adults in receipt of benefits (social security) in each constituency, downloaded from the Office for National Statistics' Nomis website (*Claimant count* series*,* monthly data averaged for 2016-18, https://www.nomisweb.co.uk/).

Wave 8 included 39,289 respondents, but respondents were excluded if they a) did not express a 'leave' or 'remain' opinion on the EU (N= 5017), b) were interviewed prior to the referendum (N=8568), c) were missing GHQ data (N=135), or d) were missing constituency data (N=14). This left 25,555 respondents across 15,425 households in all 650 constituencies. The analyses including pre-referendum scores as a covariate (Models 3-7, plus supplementary models, see below) had 19,767 respondents across 12,799 households.

Seven binomial generalised linear mixed effects models were fitted to assess whether the association between mental distress and opinion on the UK's membership of the EU was moderated by the estimated result of the referendum in their constituency. In all models, being over the threshold on the GHQ (i.e. a

GHQ score greater than 2) was the dependent variable. Opinion on EU membership, estimated proportion of leave voters in the respondent's constituency (z-scored), sex, and linear and relevant constituency' quadratic terms for age were the fixed effects. Nested random intercepts of households within constituencies were also included. Residuals were weighted by individual sampling weights.

The second model was as the basic model, outlined above, but also included income and proportion of the working age population claiming benefits, both z-scored.. Controlling for individual and area-level individual and ecological material circumstances is standard in group density studies, as economic disparities often exist between majority and minority groups.

The third model, fitted to the subset of the data where pre-referendum GHQ data were available, included pre-referendum dichotomised GHQ scores as a covariate. This was to test whether the putative ethnic density pattern developed since the referendum or whether it pre-exists it.

The fourth model was as the third but added the industry classification of the respondent's job as a covariate. Potentially some remainers living in leave-voting areas felt differently to their neighbours primarily because of the perceived threat to their livelihoods, and this explains their poorer mental health post-referendum.

The fifth was as the third but included a dichotomised measure of ethnicity plus its interaction with local leave vote. The sixth was as the third but included whether the respondent had been born in the UK, plus its interaction with local leave vote. These were to rule out any Brexit density effect being a 'standard' ethnic density effect in disguise – remainers who were migrants or members of ethnic minorities may have experienced a detriment to their mental health following the referendum due to feeling more stigmatised or less wanted by their local communities and the effect could represent an activation of these existing identities rather than the new Brexit identities.

The seventh was as the third but including a main effect of education. Education was a key correlate of Brexit voting, with those with higher levels of education favouring remain and those with lower levels favouring leave (Ford and Goodwin, 2017), but obviously represents a pre-existing set of cultural

identities. Thus finding the hypothesised density effect after controlling for education is a particularly exacting test of the hypothesis.

Control analyses

A control analysis was run on the pre-referendum portion of Wave 7, for the 23,105 respondents who could be linked to a Wave 8 opinion on leaving the EU. The model fitted had the same structure as Model 2 above. Although the above models that include pre-referendum mental health implicitly test whether any such Brexit density effect can be explained by pre-referendum patterns in mental health, explicitly fitting a model to pre-referendum data gives a tangible sense of whether any such pattern represents a meaningful change relative to before the referendum.

Although the GHQ cut off used is standard in the literature, and avoids making assumptions of interval data that are unlikely to hold for Likert data, such cut offs are still somewhat arbitrary. A second version of Model 3 was thus run on continuous GHQ scores to ensure that the 3+ cut off is not unrepresentative of the raw data.

Geographical heterogeneity of effect

Three analyses were run to check for geographical heterogeneity in the effect. One included a term for Government Offices for the Regions (GOR, a system of dividing the UK into the three non-English nations and a set of English regions) and its interactions with area-level leave vote, individual opinion, plus the three-way interaction. A second included the main effect and interaction terms for whether the respondent lived in an urban or rural area (*h_urban_dv*), a third included modelled estimates of the impact of a 'no deal' Brexit on employment of the residents of each British constituency (excluding Northern Ireland) to a 'no deal' Brexit (Winters and Serwicka, 2018), plus the associated interactions with area-level leave vote, individual opinion, and the three way interaction.

Statistical significance was assessed by overlap of the 95% confidence intervals of the odds ratio (OR) of each term in the model with 1.

Models were fitted in R (R Core Team, 2019) using the *glmmTMB* package (Brooks *et al.*, 2017). Multicollinearity was assessed using variance inflation factors, computed using the *check_collinearity* function from the *performance* package (Lüdecke *et al.*, 2019). Figures were made with the *ggplot2* package (Wickham, 2016).

Results

Descriptive statistics can be seen in Table 1. The sample was slightly more remain-supporting (58%) than leave-supporting, even after reweighting (54%), and, on average, leavers were older, more male, and reported lower incomes. Note that the sample included respondents aged 16+ while the referendum had an 18+ franchise, so it is not clear what leave/remain split would be representative of the population.

Table 2 shows the results from the seven mixed effects models. Respondents who wanted to leave the EU reported greater distress, but the main effect of constituency leave vote was not statistically significant. However, as hypothesised, the interaction of these factors was significant, such that living in a more leave-voting area was relatively protective for leavers but a risk factor for distress in remainers. Figure 1 shows this interaction in the post-referendum data and the equivalent plot for the pre-referendum data, where the group density effect is not evident.

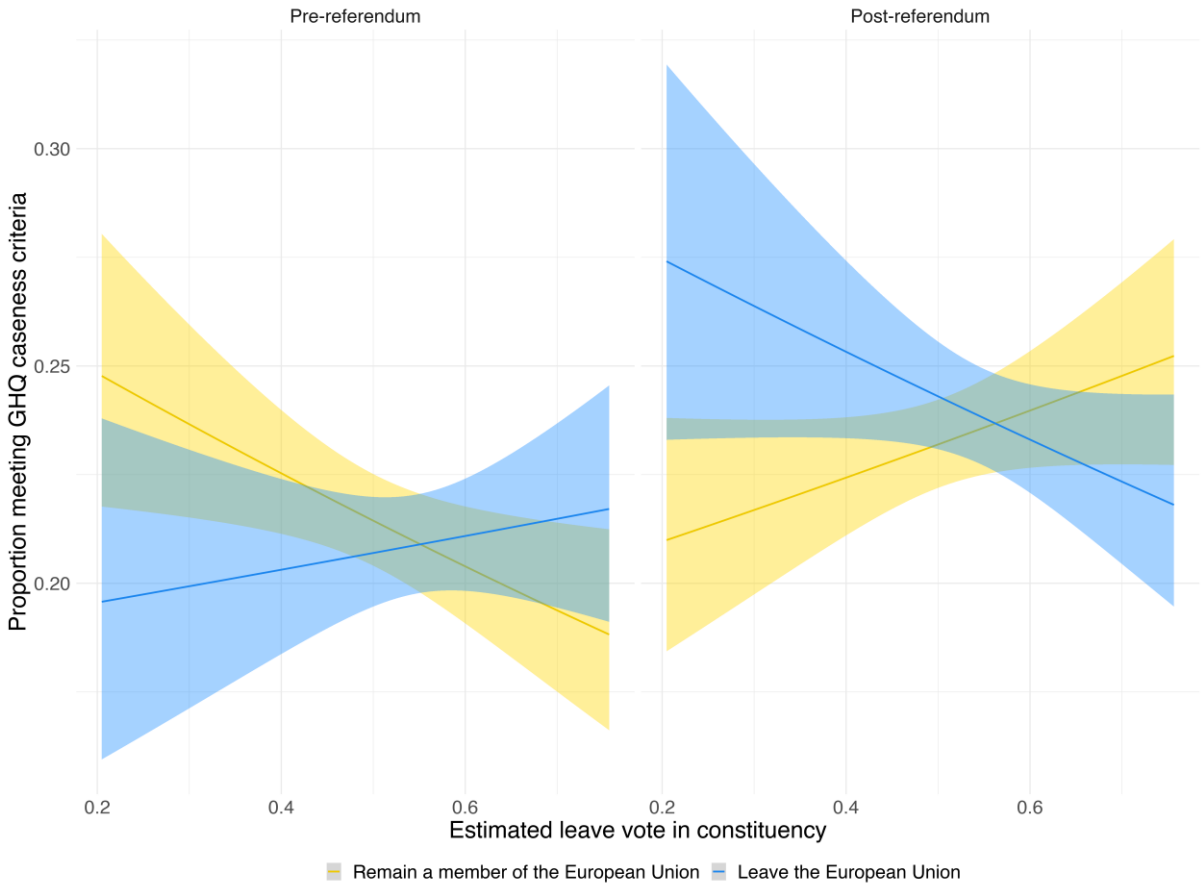

Figure 1. Linear terms for proportion reporting poor mental health (GHQ score 3+) as a function of their opinion on EU membership and the referendum result in their constituency of residence in pre and post-referendum data.

Otherwise, older age (linear term), higher income, and being male were all associated with lower risk of distress and living in a more deprived area, as indicated by benefit claimant rates, was a risk factor for distress, as was having a GHQ score over 2 pre-referendum. No industries reached statistical significance in Model 4. All variance inflation factors were 2.01 or less, indicating no evidence of multicollinearity, with the exception of Model 5 where the main effect of area-level leave voting and its interaction with ethnicity had variance inflation factors approaching 6, indicating moderate multicollinearity. Most of the variance captured on the random effects level was on the household (SD=2.008), rather than the constituency (SD=.00009) level (Model 3, similar figures across models).

	N	Sum of weights	Proportion reporting distress	Mean age [SD]	Proportion female	Income (minimum)	Income (quintile 1)	Income (quintile 2)	Income (quintile 3)	Income (quintile 4)	Income (max)
Leavers	10732	5640.384	0.232	52.53 [17.93]	0.522	-16666.67	661.264	1100	1480.552	2035.122	65857.062
Remainers	14823	6672.247	0.228	45.46 [18.24]	0.574	-3333.33	570.83	1148.33	1603.76	2306.964	89373.68

Table 1. Descriptive data for leave and remain supporting respondents.

	Model 1			Model 2			Model 3			Model 4		
Term	**OR**	**OR 2.5%**	**OR 97.5%**	**OR**	**OR 2.5%**	**OR 97.5%**	**OR**	**OR 2.5%**	**OR 97.5%**	**OR**	**OR 2.5%**	**OR 97.5%**
Leave the EU (individual)	1.2187	1.0708	1.3870	1.1854	1.0415	1.3492	1.1918	1.0101	1.4063	1.1776	1.0096	1.3737
Constituency leave vote (z-scored, SD=0.1127403)	1.0556	0.9674	1.1519	1.0344	0.9482	1.1284	1.0617	0.9480	1.1890	1.0935	0.9854	1.2134
Income (z-scored, SD=1948.259)				0.7667	0.6953	0.8456	0.8351	0.7449	0.9363	0.9438	0.8597	1.0360
Age (z-scored, SD= 18.44425, linear term)	0.8111	0.7625	0.8627	0.8428	0.7919	0.8970	0.9267	0.8523	1.0076	0.7902	0.7257	0.8604
Age (z-scored, Quadratic term)	0.9852	0.9346	1.0386	0.9483	0.8980	1.0013	0.9426	0.8762	1.0141	0.8578	0.7985	0.9217
Male	0.5797	0.5174	0.6494	0.6256	0.5571	0.7026	0.6663	0.5745	0.7729	0.7667	0.6646	0.8846
Area-level poverty (z-scored, SD=1.0399)				1.1231	1.0499	1.2014	1.1158	1.0238	1.2160	1.0776	0.9948	1.1674
Pre-referendum GHQ score >2							19.3614	14.4891	25.8722	17.1887	13.4520	21.9633
Leave the EU * Constituency leave vote	**0.8750**	**0.7660**	**0.9995**	**0.8658**	**0.7583**	**0.9887**	**0.8412**	**0.7093**	**0.9978**	**0.8314**	**0.7102**	**0.9732**

	Model 5			Model 6			Model 7		
Term	**OR**	**OR 2.5%**	**OR 97.5%**	**OR**	**OR 2.5%**	**OR 97.5%**	**OR**	**OR 2.5%**	**OR 97.5%**
Leave the EU (individual)	1.2025	1.0314	1.4019	1.1922	1.0230	1.3894	1.1500	0.9832	1.3451
Constituency leave vote (z-scored, SD=0.1127403)	1.0889	0.8963	1.3228	1.0939	0.9809	1.2199	1.0775	0.9709	1.1958
Income (z-scored, SD=1948.259)	0.8263	0.7417	0.9206	0.8250	0.7403	0.9193	0.8438	0.7562	0.9416
Age (z-scored, SD= 18.44425, linear term)	0.9286	0.8598	1.0029	0.9266	0.8583	1.0003	0.8905	0.8192	0.9680
Age (z-scored, Quadratic term)	0.9471	0.8861	1.0123	0.9433	0.8823	1.0086	0.9399	0.8774	1.0069
Male	0.6815	0.5943	0.7815	0.6830	0.5954	0.7833	0.6865	0.5981	0.7879
Area-level poverty (z-scored, SD=1.0399)	1.0975	1.0127	1.1893	1.0979	1.0134	1.1894	1.0867	1.0025	1.1779
Pre-referendum GHQ score >2	18.2594	14.2663	23.3701	18.3732	14.3342	23.5503	18.4850	14.3858	23.7523
Leave the EU * Constituency leave vote	**0.8223**	**0.7019**	**0.9634**	**0.8150**	**0.6962**	**0.9541**	**0.8239**	**0.7041**	**0.9642**
Ethnicity (White British/English/Scottish/Welsh/Northern Irish)	0.9982	0.7911	1.2594						
Ethnicity (White British/English/Scottish/Welsh/Northern Irish) * Constituency leave vote	0.9857	0.7986	1.2167						
Not born in UK				0.6413	1.0544	0.8223			
Not born in UK * Constituency leave vote				0.6812	1.0937	0.8631			
Education: Other higher degree							1.0845	0.8517	1.3808
Education: A-level etc							1.0308	0.8311	1.2785
Education: GCSE etc							1.1919	0.9543	1.4887
Education: Other qualification							1.1895	0.8974	1.5767
Education: No qualification							1.4187	1.0653	1.8893

Table 2. Odds ratios for all fixed effects in each model. Standard deviations given for all z-scored variables. Terms for different industries not presented for Model 4 for reasons of space and readability, but none were statistically significant. Note also that models 3-7 fitted to fewer (N=19,767) participants.

Model 1 code: *glmmTMB(GHQ_Case ~ h_eumem * scale(LeaveVote) + poly(scale(h_age_dv), 2, raw = T) + h_sex + (1| h_pcon/h_hidp), data = US, weights = h_indinus_lw, family = 'binomial')*

Model 2 code: `glmmTMB(GHQ_Case ~ h_eumem * scale(LeaveVote) + scale(Income) + poly(scale(h_age_dv), 2, raw = T) + h_sex + scale(ClaimantCount1618) + (1| h_pcon/h_hidp), data = US, weights = h_indinus_lw, family = 'binomial')`

Model 3 code: `glmmTMB(GHQ_Case ~ h_eumem * scale(LeaveVote) + scale(Income) + GHQprereferendum + poly(scale(h_age_dv), 2, raw = T) + h_sex + scale(ClaimantCount1618) + (1| h_pcon/h_hidp), data = US_prerefGHQ, weights = h_indinus_lw, family = 'binomial')`

Model 4 code: `glmmTMB(GHQ_Case ~ h_eumem * scale(LeaveVote) + scale(Income) + GHQprereferendum + h_jbiindb_dv + poly(scale(h_age_dv), 2, raw = T) + h_sex + scale(ClaimantCount1618) + (1| h_pcon/h_hidp), data = US, weights = h_indinus_lw, family = 'binomial')`

Model 5 code: `glmmTMB(GHQ_Case ~ h_eumem * scale(LeaveVote) + EthnicityDichotomised + EthnicityDichotomised:scale(LeaveVote)+ scale(Income) + GHQprereferendum + poly(scale(h_age_dv), 2, raw = T) + h_sex + scale(ClaimantCount1618) + (1| h_pcon/h_hidp), data = US_prerefGHQ, weights = h_indinus_lw, family = 'binomial')`

Model 6 code: `glmmTMB(GHQ_Case ~ h_eumem * scale(LeaveVote) + bornuk_dv + bornuk_dv:scale(LeaveVote)+ scale(Income) + GHQprereferendum + poly(scale(h_age_dv), 2, raw = T) + h_sex + scale(ClaimantCount1618) + (1| h_pcon/h_hidp), data = US_prerefGHQ, weights = h_indinus_lw, family = 'binomial')`

Model 7 code: `glmmTMB(GHQ_Case ~ h_eumem * scale(LeaveVote) * h_hiqual_dv + scale(Income) + GHQprereferendum + poly(scale(h_age_dv), 2, raw = T) + h_sex + scale(ClaimantCount1618) + (1| h_pcon/h_hidp), data = US_prerefGHQ, weights = h_indinus_lw, family = 'binomial')`

Control analyses

The control analysis of pre-referendum data did not show the same pattern as post-referendum, Indeed the interaction non-significantly trended in the opposite direction, with both groups' mental health worsening with increasing own-group density (see Figure 1). A table of coefficients for this model can be found in the supplementary materials.

Geographical heterogeneity of effect

The analyses by different GORs had extremely high levels of multi-collinearity (VIFs as high as 1753368.30!) so results cannot be interpreted. Although a formal analysis is not presented, a figure of the interaction broken down by region is included in the supplementary materials. As the sample size is split (unevenly) sixteen ways, these are rather noisier than the main analysis, but the pattern appears reasonably consistent across most of the nations and regions. A key exception is Northern Ireland, where Brexit seems, understandably, not to have supplanted existing historical social divides. Most GOR areas show the pattern from the full dataset however.

The models looking at moderation by rurality and by estimated economic vulnerability to a 'no deal' Brexit found no such moderations and the other terms in the model were similar to those in Model 3 (the density effect remained statistically significant in both cases). Tables of the coefficients for these models can be found in the supplementary materials.

Discussion

Analyses of large-scale geographically-linked panel survey data on over 25,000 respondents show that the association between opinion on the UK's EU membership and mental health is moderated by local political sentiment, such that being in a local political minority is a risk factor for poor mental health. This relationship was not explained by differences between remainers and leavers in age, gender, income, industry worked in, or by neighbourhood poverty. The pattern is also not explained by ethnic group or whether respondents were born in the UK, or the interactions of these characteristics with local leave vote. Most strikingly, after controlling for pre-referendum mental health in a subset (77%) of the data, the

interaction remained statistically significant. This pattern was not seen in pre-referendum data, appearing to have developed since the referendum.

In political terms, this is strong evidence of the degree of polarisation in the UK in the aftermath of the EU referendum. Where previous survey evidence (Hobolt *et al.*, n.d.) used explicit questions about respondents' opinion of leavers and remainers, or asked specifically about mental health consequences of the referendum as a result of discrimination (Frost, 2020) the present study uses differential associations across geography on a question about mental health not obviously related to Brexit. Doing so, it appears that the level of division is sufficient to lead to consequences for public mental health on both sides of the issue. Replications of this phenomenon in other countries where similar processes of political polarisation and realignment are underway (McCoy and Somer, 2019), would be interesting.

In terms of what this tells us about group density effects, this finding is a striking example of a group density effect associated with a rapidly formed political identity, rather than a more static identity like ethnicity (Simpson *et al.*, 2016). This, combined with the use of pre-referendum data allows greater confidence that the mechanism behind this effect was indeed these newly formed political identities, rather than the intersection of longer term trends in UK social geography outlined above (Jennings and Stoker, 2019) with current cultural conflicts in the UK (Ford and Goodwin, 2017). Such a finding is novel in the group–density-effect literature and consistent with predictions from social identity theory (Tajfel and Turner, 1979).

Furthermore, Brexit is a case where the power relations between the two groups are somewhat ambiguous. While leavers hold political and electoral power, as confirmed by the 2019 UK General Election that followed, the descriptive statistics show that remainers were on average more personally affluent (although on the area level there was a u-shaped relationship between benefit claimant rates and leave voting). Much of the ethnic density literature examines groups clearly in the minority, and theoretical accounts of minority mental health, such as the minority stress model (Meyer, 1995) or post-colonial approaches (Bécares *et al.*, 2013), identify this unambiguous power gradient as a key component of the proposed mechanism. These findings emphasise the importance of the local circumstances, rather

than broader power structures, although the relative importance of an unambiguous power gradient may depend on the specific situation.

A few limitations and caveats of the study should be acknowledged. Firstly, it is possible that the socioeconomic correlates of one's opinion on EU membership varied geographically, such that the differing mental health of remainers in remain and leave-voting areas represented a compositional, rather than contextual, effect. This was the motivation behind controlling for respondents' industry of employment – perhaps remainers in leave-voting areas were disproportionately likely to work in industries where they perceived Brexit as especially threatening (financial services or supply chain manufacturing for example) and job insecurity explained the elevated distress post-referendum. Although this was controlled for, it is not possible to rule out other compositional differences between remainers in remain and in leave voting areas (or likewise for leavers), or that the data on industry were insufficiently fine-grained to control for this issue. Secondly, the analyses were based on self-report measures, rather than diagnostic, behavioural, or medication-based measures. Although Understanding Society does ask about clinical diagnoses of depression, only a small number of respondents reported a diagnosis (218 of the eventual sample used), far too few to detect the interaction of interest. Furthermore, the GHQ is designed to capture recent declines in mood in a way that would be responsive to events like Brexit, whereas a diagnosis or medication would likely only be given following a certain duration of poor mental health, so would not be sensitive in the situation studied. The GHQ is also designed to capture minor psychiatric issues on the population level, so seemed like a good measure given the effect size one might plausibly expect (although see Katshu, 2019 for an example of a more dramatic mental health reaction to Brexit). Thirdly, although the rapid formation of Brexit identities and control for pre-referendum mental health, allow us to be more confident about mechanisms than previous group density studies, it is possible that individual opinions on the EU or area-level leave vote were proxies for the true causal mechanism. Although the identities of remainer and leaver were novel and newly salient, they come from pre-existing cultural cleavages in the UK (Ford and Goodwin, 2017). That said, that the group density effect survived adjusting for pre-referendum mental health, and was not present pre-referendum, suggests that the social identities themselves were key to the effect. Fourthly, it would have been useful to have modelled a 'traditional' ethnic density effect (*i.e.* an area-level measurement of own-group ethnic density and its interaction with individual-level ethnicity) in the same model as the Brexit density effect,

to be fully confident that the latter was not dependent on the former. Unfortunately this was not possible for reasons of multicollinearity as leave vote was negatively correlated with the ethnic diversity of constituencies – indeed the inclusion of individual-level ethnicity in Model 5 led to a moderate level of multicollinearity in this model. Fifthly, the proportion of the population claiming benefits was used as an area-level measure of poverty. This not as sophisticated as multidimensional measures of poverty such as the Welsh Indices of Multiple Deprivation (Welsh Government, 2014), or their English, Scottish, or Northern Irish equivalents. However these measures are presented as ranks, so are not comparable between nations, and are also not given at the constituency level, so were not appropriate for use here. However, it should be acknowledged that some residual confounding by economic deprivation is likely to be present in the estimates of interest. Finally, many studies of ethnic density effects focus on severe outcomes such as psychosis, whereas the present study examines much milder psychological distress. Clearly these outcomes should not be equated and no conclusions can be drawn on the relative magnitude of this Brexit density effect and ethnic density effects employing such outcome measures.

To conclude, the present study demonstrates clear evidence of a group density effect on mental health following the UK's referendum on EU membership, based on survey respondents' views on EU membership and the result in their area of residence. This finding is not explained by plausible compositional confounds or by pre-referendum patterns in mental health. These results broaden evidence of group density effects from ethnic groups and social characteristics to political differences, which is especially notable due to the rapidity with which the political identities in question developed.. It also confirms the extent of political polarisation in the UK, in the aftermath of the Brexit referendum.

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Supplementary material

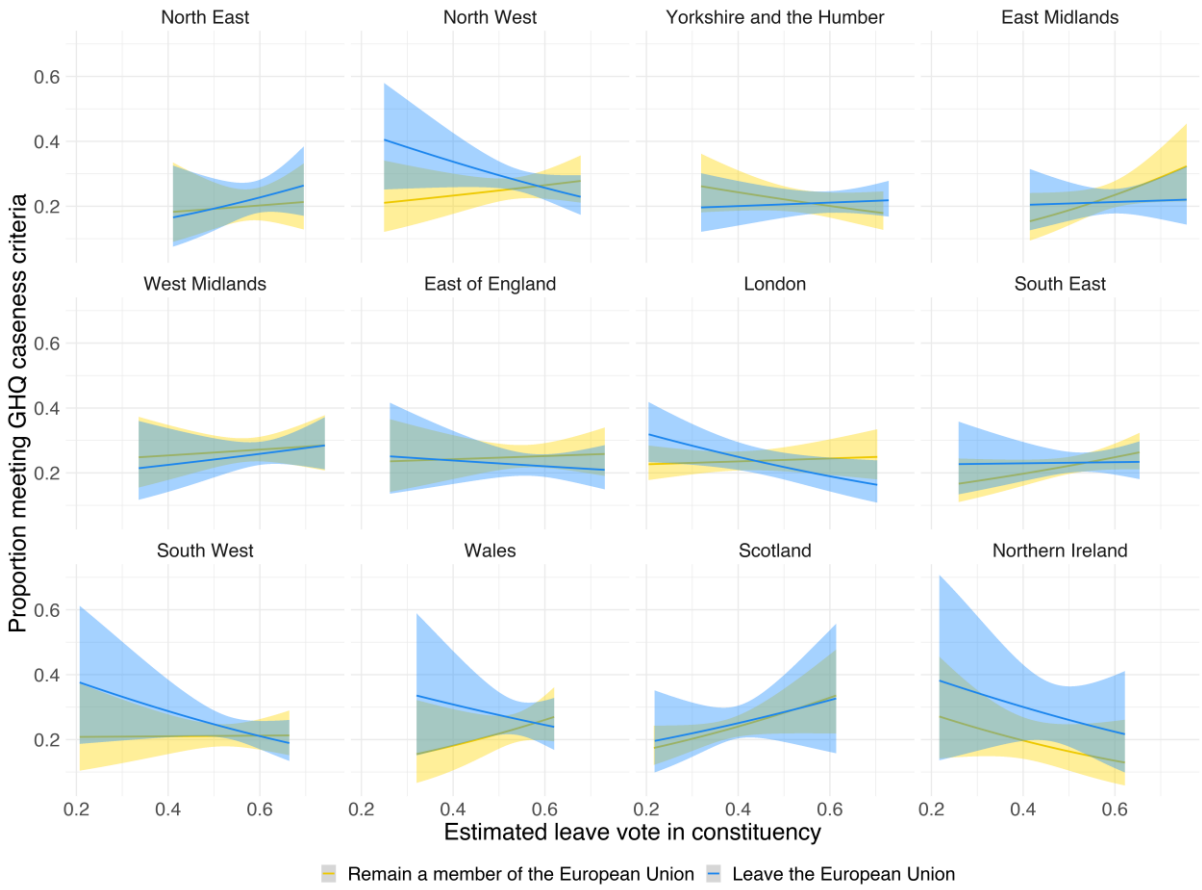

Figure A. Post-referendum density effect by Government Office of the Regions area.

	Model A - Urban/rural			Model B - Impact of 'no deal' Brexit on employment		
	Estimate	2.50%	97.50%	Estimate	2.50%	97.50%
Leave the EU (individual)	1.2450	1.0456	1.4826	1.1949	1.0135	1.4088
Constituency leave vote (z-scored, SD=0.1127403)	1.0985	0.9818	1.2290	1.1281	1.0060	1.2650
Income (z-scored, SD=1948.259)	0.8203	0.7358	0.9145	0.8197	0.7344	0.9149
Age (z-scored, SD= 18.44425, linear term)	0.9226	0.8546	0.9960	0.9110	0.8423	0.9852
Age (z-scored, Quadratic term)	0.9525	0.8911	1.0182	0.9550	0.8920	1.0224
Male	0.6846	0.5968	0.7852	0.6864	0.5967	0.7895
Area-level poverty (z-scored, SD=1.0399)	1.0838	0.9977	1.1772	1.0909	1.0039	1.1855
Pre-referendum GHQ score >2	18.5184	14.4282	23.7680	19.0513	14.6451	24.7831
Leave the EU * Constituency leave vote	**0.8022**	**0.6765**	**0.9513**	0.7727	0.6516	0.9164
Rural area	0.9656	0.7546	1.2357			
Leave the EU * Rural area	0.8156	0.5706	1.1659			
Constituency leave vote * Rural area	0.9365	0.6911	1.2690			
Leave the EU * Constituency leave vote * Rural area	1.1844	0.7570	1.8533			
Consituency employment loss				0.9339	0.8386	1.0401
Leave the EU * Consituency employment loss				1.1354	0.9683	1.3312
Constituency leave vote * Consituency employment loss				1.0381	0.9262	1.1634
Leave the EU * Constituency leave vote *Consituency employment loss				0.9894	0.8339	1.1739

Supplementary table A. Results of models looking at geographical moderators of Brexit density effect. Model A looks at moderation by urban or rural residence of respondent. Model B looks at moderation by the Winters and Serwicka estimates of the impact of a ‘no deal’ Brexit on employment in each constituency.

Term	OR	OR 2.5%	OR 97.5%
Leave the EU (individual)	1.079	0.936	1.243
Constituency leave vote (z-scored, SD=0.1127403)	0.912	0.833	0.998
Income (z-scored, SD=1948.259)	0.668	0.524	0.852
Age (z-scored, SD= 18.44425, linear term)	0.726	0.677	0.778
Age (z-scored, Quadratic term)	0.969	0.912	1.028
Male	0.609	0.536	0.692
Area-level poverty (z-scored, SD=1.0399)	1.062	0.988	1.142
Leave the EU * Constituency leave vote	1.098	0.953	1.264

Supplementary table B – The equivalent of Model 2 fitted to pre-referendum data

Term	B	B 2.5%	B 97.5%
Leave the EU (individual)	0.135	0.024	0.246
Constituency leave vote (z-scored, SD=0.1127403)	0.038	-0.037	0.114
Income (z-scored, SD=1948.259)	-0.118	-0.171	-0.065
Age (z-scored, SD= 18.44425, linear term)	-0.074	-0.129	-0.019
Age (z-scored, Quadratic term)	-0.066	-0.113	-0.018
Male	-0.257	-0.352	-0.162
Area-level poverty (z-scored, SD=1.0399)	0.100	0.040	0.159
Pre-referendum GHQ score >2	2.772	2.650	2.894
Leave the EU * Constituency leave vote	**-0.125**	**-0.240**	**-0.010**

Supplementary table C – A version of Model 3 with continuous GHQ data.